Spiking + Oja + LCA = image comprehension and compression

Equations governing our 2 months at the Darpa Innovation House in Arlington, VA

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Average firing counts over interval τ:

$$n_j^{\tau}(t+\Delta t) = e^{\frac{-\Delta t}{\tau}} \left[A_j(t) + n_j^{\tau}(t) \right] \tag{1}$$

Average firing rate over interval τ:

$$f_i^{\tau}(t) = \frac{n_i^{\tau}(t)}{\tau} \tag{2}$$

Feed-forward weight adaptation:

$$\begin{aligned} \Delta Q(t) &= \beta \left\{ [Oja] \cdot [STDP] - decay \right\} \\ Q_{ij}(t+\Delta t) &= Q_{ij}(t) + \beta \, \{ \\ & f_{Y_j}^{\tau_{oja}}(t) \left[f_{X_i}^{\tau_{oja}}(t) - Q_{ij}(t) f_{Y_j}^{\tau_{oja}}(t) \right] \cdot \\ & \left[\lambda_P A_Y(t) f_{X_i}^{\tau_P}(t) - \lambda_D A_{Xi}(t) f_{Y_j}^{\tau_D}(t) \right] - \\ & \alpha_{dec} Q_{ij}(t) \, \} \end{aligned} \tag{3}$$

where β is a learning rate:

$$\beta = dwMax \cdot \frac{\Delta t}{\tau_{oja} f_o}$$

Neuron adaptive firing threshold:

$$V_j^{th} = V_j^{adpt} + e^{\frac{-\Delta t}{\tau_{V_{th}}}} \left(V_j^{th} - V_j^{adpt} \right) \tag{4}$$

where

$$\begin{aligned} V_j^{adpt}(0) &= V_j^{thRest} \\ V_j^{adpt}(t+\Delta t) &= V_j^{adpt}(t) + \frac{\Delta t}{\tau_{THR}} \left[f_j^{\tau_o}(t) - f_o \right] \frac{V_{scale}}{f_o} \end{aligned} \tag{5}$$

Lateral inhibition:

$$w_{jk}(t+\Delta t) += \frac{\Delta t}{\tau_{INH}} \left[f_j^{\tau_{LCA}}(t) f_k^{\tau_{LCA}}(t) - f_o^2 \right] \frac{1}{f_o^2} \tag{6}$$

Current scales for τ values

$$\tau_{oja} \approx 50 - 200ms$$

$$\tau_P \approx 10 - 20ms$$

$$\tau_D \approx 20 - 40ms$$

$$\tau_{LCA} \approx \tau_{oja}$$

$$\tau_o = \frac{1}{f_o}$$

$$\tau_{THR} \gg \tau_o$$

$$\tau_{INH} \gg \tau_{LCA}$$

$$\tau_{V_{th}} \approx 5ms$$

Current values for constants:

$$V_{thRest} = -55mV$$

$$V_{rest} = -70mV$$

$$V_{scale} \approx V_{thRest} - V_{rest}$$